DEVELOPING THE COAL MINE GAS RESOURCE

Mr Raymond C Pilcher
President
Raven Ridge Resources Incorporated
USA

Developing Vietnam's Coal Mine Methane Resource: Opportunities for Power Generation

Raymond C. Pilcher

Abstract

Coalbed methane is methane contained in coal or surrounding strata. When this gas is released from coal or rock strata during the process of mining, it is termed coal mine methane (CMM). Because this gas contains other constituents, it is sometimes referred to as coal mine gas. Methane is a major safety hazard for coal miners, and hundreds of miners worldwide die each year from methane explosions. Numerous coal mines have implemented methane drainage programs for the purpose of increasing mine safety, with successful results. Many of these mines have also realized additional benefits from on-site use or sale of the drained methane.

Much of the methane that is recovered from coal mines, particularly in the U.S., is sold to pipelines for direct use, but use for power generation is growing as it is often the most economical and practical utilization option. Successful CMM-fueled power generation projects operate in Australia, China, Poland, the U.K., and the U.S. CMM can be used to generate power on-site to meet the needs of the mine only, or excess power can be sold to the grid. Both IC engines and turbines can be used to generate electricity. Fuel cells and microturbines offer promising options for using CMM in the future. CMM power generation project sizes can vary widely. Examples range from a 675 kW project in the U.S. to a 94 MW project in Australia.

In considering a CMM fueled power project, it is necessary to first determine the volume and producibility of the CMM resource. Economic considerations include capital and operating costs of IC engine, turbine, or other system; the cost to establish a CMM drainage system (if not already present); and the price of electricity or other fuel with which CMM-generated power will be competing. Based on the cost associated with production and use of the CMM resource, the project developers can estimate the magnitude of commercially producible gas reserves and then evaluate the economic performance of the project.

Utilization of CMM could help meet Vietnam's electricity needs while providing other benefits, including: increased safety and reduced costs resulting from methane drainage; revenue from sale of the electricity, or avoided electricity (or other fuel) purchase costs; and reduced particulate, SO_X, NO_X, and greenhouse gas emissions, compared to coal combustion.

Developing Vietnam's Coal Mine Methane Resource: Opportunities for Power Generation

Presented by:
Raymond C. Pilcher

RAVEN RIDGE RESOURCES
INCORPORATED

3RD APEC Coal TILF Workshop

7 November 2000

1

Overview of Presentation

- Introduction to coal mine methane (CMM)
- Background on CMM drainage
- Using drained CMM in power generation
- Evaluating a mine's methane resource
- Economic considerations
- Conclusions

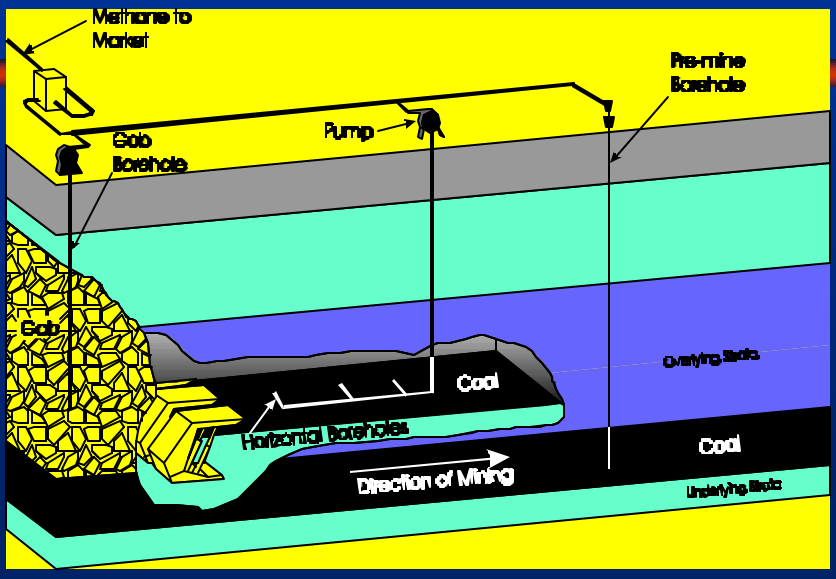
Terminology

- *Coalbed Methane* (CBM) is methane contained in coal or surrounding strata. When this gas contains other constituents, it is sometimes referred to as coal seam gas.
- *Coal Mine Methane* (CMM) is methane gas that is released from coal or surrounding rock strata during the process of mining. When this gas contains other constituents, it is sometimes referred to as coal mine gas.

Why Drain Methane From Coal Mines?

- Methane is a major safety hazard for coal miners - hundreds of miners worldwide die each year from methane explosions (e.g. January 1999 disaster at Mao Khe mine in Quang Ninh, and recent disasters in China)
- Mines originally drained methane solely for the purpose of increasing mine safety
- Today, many mines reap an additional benefit by *utilizing or selling* the drained methane—for on-site heating and coal drying, pipeline injection or power generation

Methane Drainage Using Pre-Mine, Gob, and Horizontal Boreholes



Utilization of CMM from Gassy Mines is Widespread

- ★CMM utilization takes place in the U.S., China, Australia, several European countries, Russia, and Ukraine
- ★Much of the recovered CMM is sold to pipelines for direct use, but use for power generation is growing
  - ☆Successful CMM-fueled power generation projects operate in Australia, China, Poland, the U.K., and the U.S.

Power Generation is Often the Best CMM Utilization Option

- While CMM can be compressed and injected into pipelines, it is usually more economic to use it generate power for on-site use at the mine, with sale of any excess to the grid.
  - Gas drained from gob and in-mine boreholes is typically less than 85% methane, suitable for power generation but not pipeline injection.
  - It is typically easier and cheaper to utilize existing power lines than to build pipelines and compression facilities.
  - Portable, skid-mounted IC engines permit low-cost power generation in remote areas

Power Generation Project Options

- CMM can be used to generate power on-site to meet the needs of the mine only, or excess power can be sold to the grid
- CMM can be used in IC engines or turbines, and for cogeneration
- Fuel cells and microturbines offer promising options for the future
- Project sizes can vary widely as shown in the following case studies

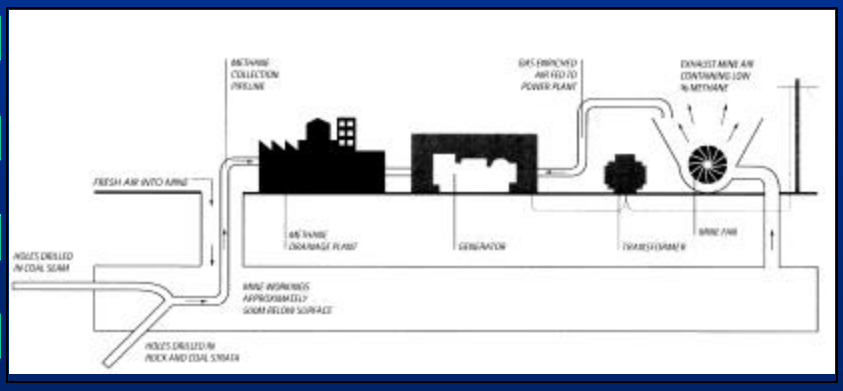
Case Study: Appin/Tower Collieries, Australia

Photo courtesy Energy Developments Ltd.

Case Study: Appin/Tower Collieries, Australia (continued)

- Energy Developments Ltd. (EDL) uses CMM from BHP's Appin and Tower Collieries to generate power for the grid
- Utilizes multiple (94) 1 MW IC engines to generate electricity during peak demand
- 4 to 10 MW is fed back from the grid to meet the mines' energy needs
- Utilizes about 566,600 m^3 of methane daily
- Fuel gas composition varies from 50-85%
- Also uses mine ventilation air (0.5-1.0% CH_4) as combustion air

Case Study:
Appin/Tower Collieries, Australia
(continued)



Schematic Courtesy of Energy Developments, Ltd.

Case Study:
Nelms Mine, Ohio USA

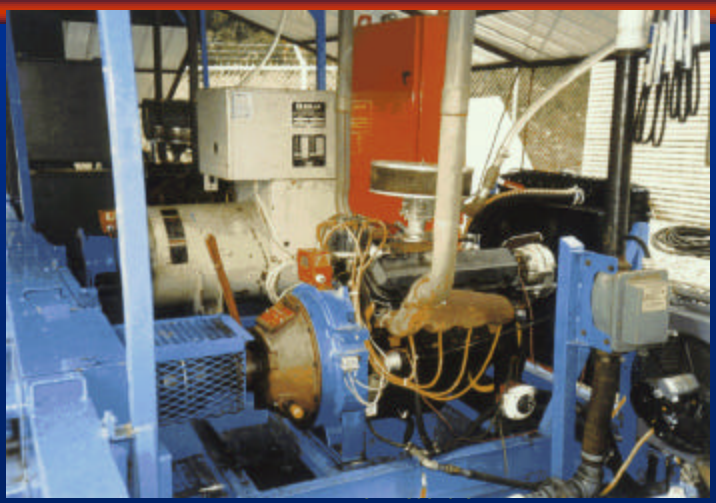


Photo courtesy of Northwest Fuel Development, Inc. and U.S. DOE

Case Study: Nelms Mine, Ohio USA (continued)

- Utilizes 100 hp IC engine
- Uses gas ranging from 30%-100% CH_4
- Nine-unit system generates 675 kW
- System uses 6,370 m^3 of CMM per day
- Installed costs of generator sets less than $US 800/kW
- Electricity meets operating needs of mine

Case Study: Sihe Mine, Shanxi Province, China

- CMM-fueled power plant currently uses four 400 kW gas engines for a total capacity of 1600 kW.
- A 2 x 2000 kW gas turbine-based power plant is being tested, and will be put into full operation late this year or early next year.
- Together, these power generation plants will consume 14.6 Mm^3 of CMM per year

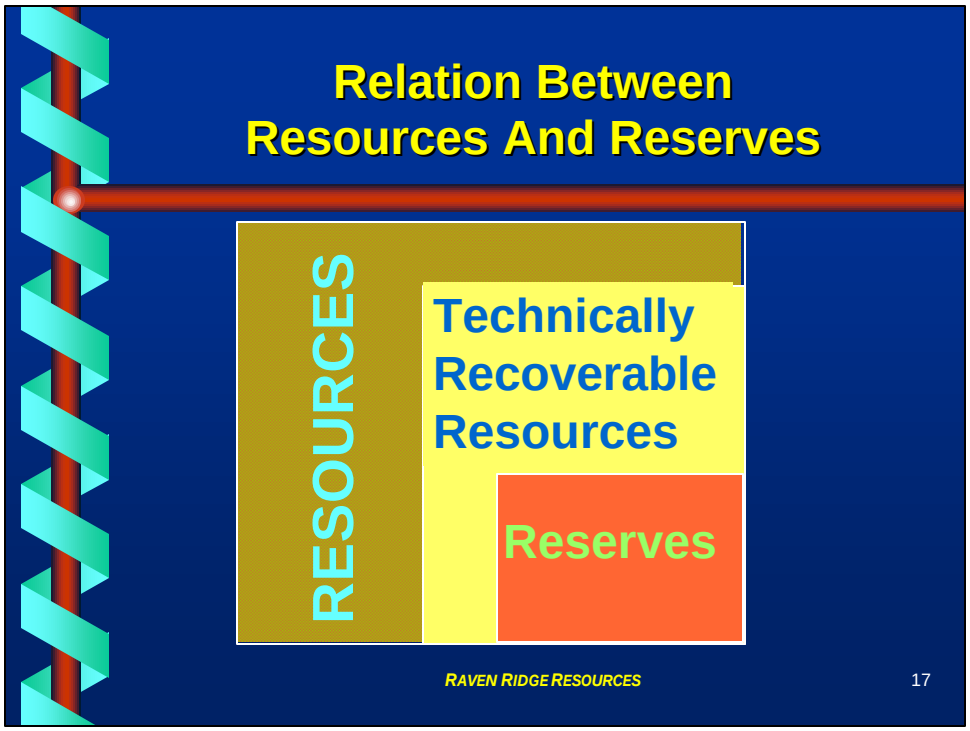
Determining Project Feasibility

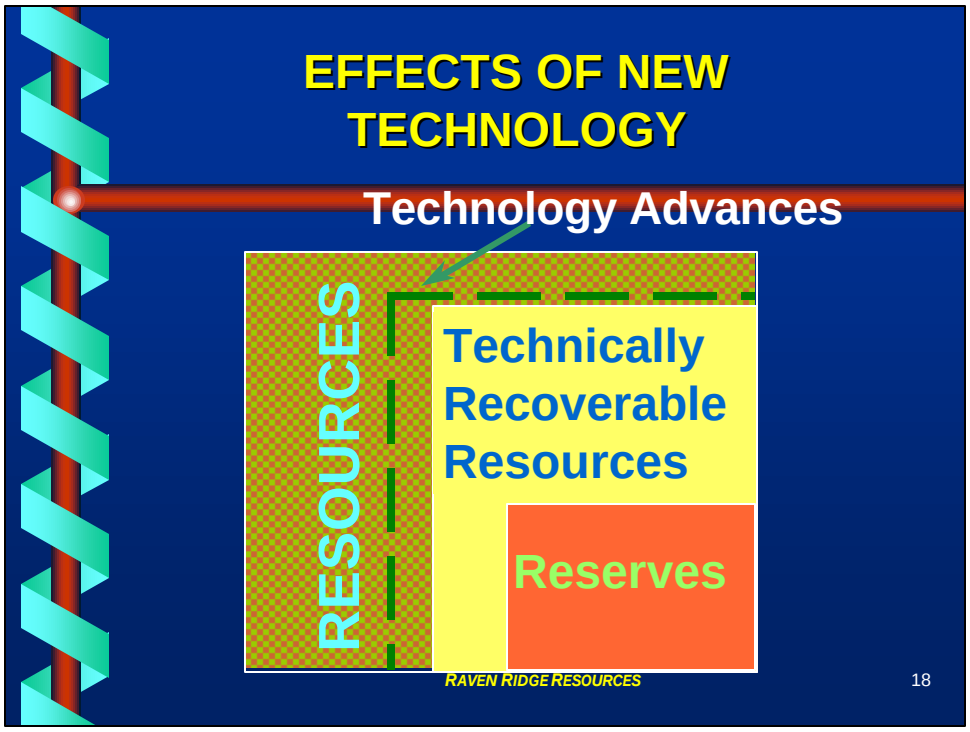
- Need to determine quantity and producibility of the CMM resource
- Need to determine cost of producing electricity using CMM vs. price of electricity from other sources

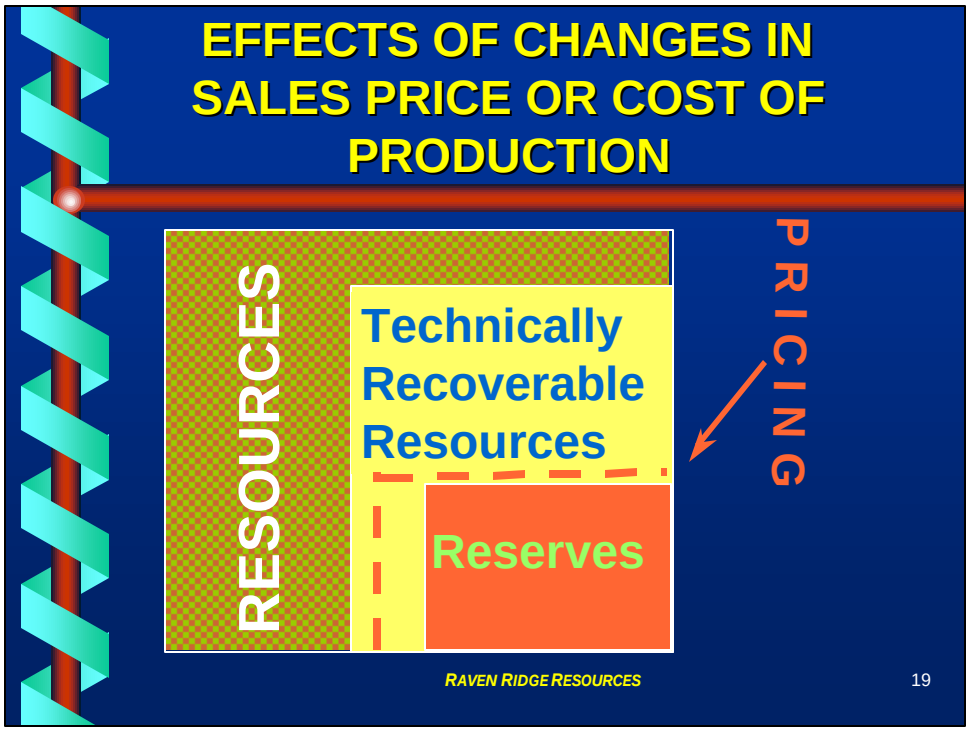
Understanding the Methane Resource

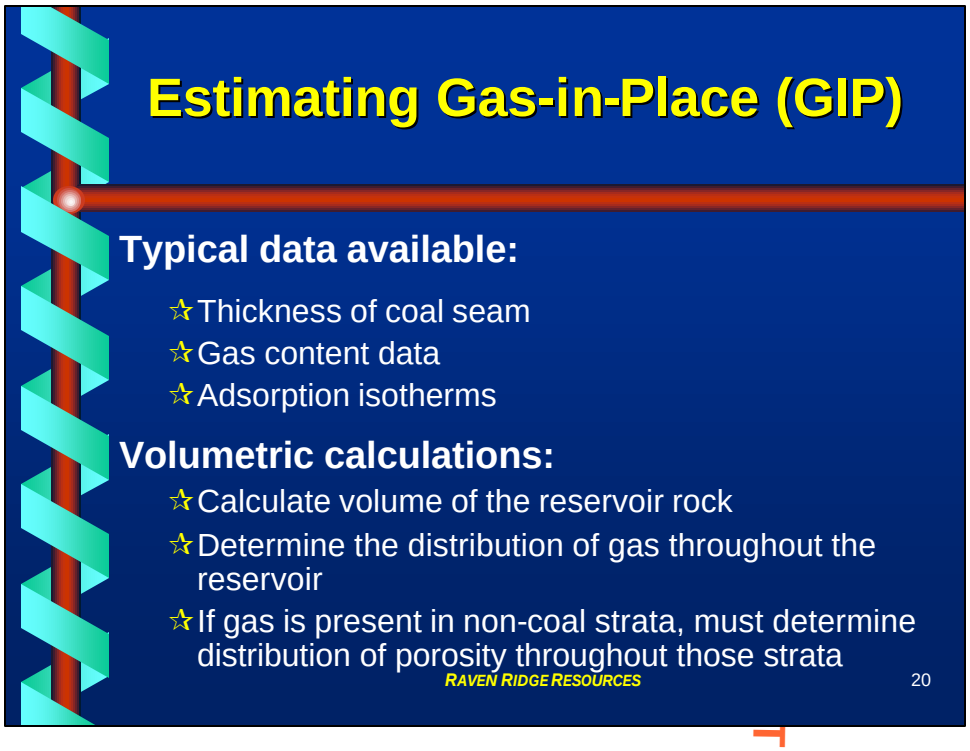
Resource - volume of gas in coal and surrounding strata (**gas-in-place**)

- ***Technically recoverable*** *resource* is that gas which is recoverable using proven modes of extraction and existing technology
- ***Reserves*** are the commercially extractable portion of the technically recoverable resource


Relation Between
Resources And Reserves
RESOURCES
Technically
Recoverable
Resources
Reserves
RAVEN RIDGE RESOURCES
17


EFFECTS OF NEW
TECHNOLOGY
Technology Advances
RESOURCES
Technically
Recoverable
Resources
Reserves
RAVEN RIDGE RESOURCES
18


EFFECTS OF CHANGES IN SALES PRICE OR COST OF PRODUCTION
RESOURCES
Technically Recoverable Resources
Reserves
PRICING
RAVEN RIDGE RESOURCES
19


Estimating Gas-in-Place (GIP)
Typical data available:
Thickness of coal seam
Gas content data
Adsorption isotherms
Volumetric calculations:
Calculate volume of the reservoir rock
Determine the distribution of gas throughout the reservoir
If gas is present in non-coal strata, must determine distribution of porosity throughout those strata
RAVEN RIDGE RESOURCES
20
TS

Estimating Gas in Place (continued)

Easier with use of computer software applications

- ☆Integrated software applications use an areal grid and data values to fit a surface to the data
- ☆May calculate GIP simply by using gas content data
- ☆Such estimates do not account for uncertainty of using single point estimates

Development of a Forecast for GIP

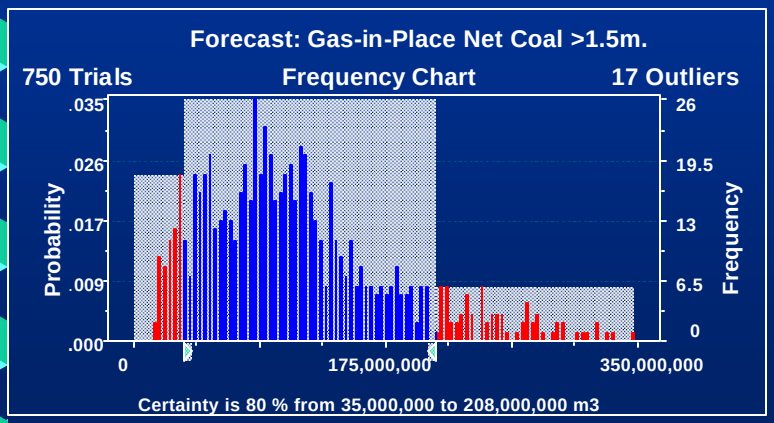
Collect:

- ★**Gas content data**
- ★**Specific gravity measurements**
- ★**Coal thickness data**

Calculate GIP Distribution:

- ★**Develop frequency distributions for coal-in-place using specific gravity and thickness distributions**
- ★**Calculate a range of gas-in-place values by multiplying randomly sampled coal-in-place values by randomly sampled gas content values**

Gas In-Place Forecast Showing Probability Of Occurrence Of Each Class



Estimating Technically Recoverable Resources

Recovery factor **is the fraction of the total resource that is recoverable. Can estimate...**

- ☆ **Based on experiences in similar geologic regions and mining conditions, or**
- ☆ **Through computational fluid dynamics (CFD) modeling, which uses numerical techniques to predict gas emission rate**

Estimating Economically Recoverable Resources and Reserves

- Once development plan is proposed, the CFD model can help generate a reserve estimate
- ***Proved reserves*** are those quantities of gas which are commercially recoverable

Economic Considerations

- Capital and operating costs of IC engine, turbine, or other system
- Cost to establish CMM drainage system (if not already present)
- Price of electricity or other fuel with which CMM-generated power will be competing

Potential Benefits

- Methane drainage increases safety and lowers costs associated with methane-related mining delays
- CMM-generated power provides revenue from sale of electricity, or avoids the cost of purchasing electricity or other fuels
- Using CMM rather than coal frees up coal for sale
- Greatly reduced particulate, SO_X, NO_X, and compared to coal combustion
- Reduced emissions of greenhouse gases (CH_4 and CO_2) compared to coal combustion

Conclusions

- Recovery and utilization of CMM can improve safety and profitability at gassy coal mines
- There are many successful CMM-fueled power generation projects worldwide
- Utilization of CMM could help meet Vietnam's electricity needs